UTILIZATION OF EARTHWORMS IN ORGANIC WASTE MANAGEMENT

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Abstract

Vermicomposting is an ecofriendly, socially sound and economically viable technology to manage the organic waste resources. It is popular particularly in India, because it is the cheapest solution to overcome the dangerous effects of modernized agriculture. The aim of the present study was to evaluate the efficiency and the nutritional status of vermicompost processed by two earthworm species, *Eisenia fetida* and *Eudrilus eugeniae* from leaf litter and sugarcane trash. Chemical analysis of the vermicompost obtained from leaf litter showed that the quantity of organic carbon was reduced from 38.65 to 28.89 and 28.0% by *E. fetida* and *E. eugeniae* respectively. The level of nitrogen (1.30%), phosphorus (0.38%), potassium (0.57%) and calcium (0.70%) was maximum in leaf litter vermicompost processed by *E. eugeniae* than *E. fetida*. Similarly, *E. eugeniae* processed leaf litter compost treated with plant, *Abelmoschus esculentus* showed maximum height (61.4cm), number of leaves (16 per plant), leaf area (265 cm^2), fruit length (15.8cm), fruit weight (17.9gm) and total chlorophyll content (3.78 mg/g.fresh wt) than those treated with sugarcane trash.

Key words: Eisenia fetida, Eudrilus eugeniae, Abelmoschus esculentus

1. INTRODUCTION

One of the major problems associated with urbanization is the disposal of large amount of solid wastes generated from domestic, industries and agricultural residues. The accumulation of such wastes is increasing in an alarming way leading to the greater environmental degradation. Agriculture provides plenty of waste consisting of crop straw, husk, sugarcane trash, groundnut shells and generation of these wastes in India have been estimated to be 363 million tonnes annually (Chaudhary *et al*., 2004). Uncared dumping of leaf litter in public places and in the premises of educational institutions might lead to decomposition of solid wastes particularly during rainy season resulting in air, water and soil pollution. It also causes social, ecological, aesthetic and economic problems having a negative impact on human health and quality of life (Techobanoglous *et al*.1993). Hence, these wastes must be treated holistically, recognizing their natural resource origin as well as health impacts. All these problems encourage revival of old traditional techniques of compost production and organic farming which are nature's ways to renew life. During composting, the waste organic materials are broken down into different viable organic products that can be added to the soil without detrimental effects on crop growth. Compost improves soil structure, texture, and aeration and increases the soil's water-holding capacity. The organic matter produced in compost provides food for micro-organisms, which keeps the soil healthy and suppress diseases in plants (Hari *et al.,* 2004). As this conventional method of composting takes a long time to produce compost, earthworms are inoculated with organic wastes which speed up the process of composting (Vermicomposting) and enhanced nutritional quality of the composts. Earthworms form a major component of the soil system and represent a key component in nutrient cycling of soils. In recent years researchers have become progressively interested in using earthworms for breaking down and stabilizing the wide variety of organic wastes (Atiyeh *et al*., 2000). The ability of some species of earthworms to consume and breakdown a wide range of organic residues especially crop residues is well known (Karmegam and Daniel, 2009; Patnaik and Reddy, 2010). The microorganisms present in the gut of earthworm help in degradation of organic materials (Edwards and Bohlen, 1996).

The most frequently used earthworm species for vermicomposting are *Eisenia fetida* and *Eudrilus eugeniae.* The earthworm, *E. eugeniae* is commonly known as African worm or Night crawlers. It is a large composting worm, less tolerant to cold temperatures and best suited to tropical conditions. It is epigeic, lives on the surface of the soil or in the top 10 inches from the surface or on the topsoil under the litter layers. *E. fetida* popularly known as European worm is also epigeic, can tolerate wide temperature ranges. *E. fetida* is commonly found in compost heaps, forests, gardens, under stones and logs. The present study was aimed to evaluate the efficiency and nutritional status of the vermicompost and its effect on *Abelmoschus esculentus,* processed from the leaf litter and sugarcane trash by two earthworms, *E. fetida* and *E. eugeniae*.

2. MATERIALS AND METHODS

2.1. COLLECTION OF COMPOST MATERIALS

The leaf litter was collected from Yadava College campus and the sugarcane trash from the Alanganallur Sugar factory and were shredded to a length of 2-3 cm pieces, dried for a week and then subjected to pre decomposition. These wastes were mixed with equal amount of fresh cow dung in plastic troughs separately and allowed for predigestion by sprinkling water. After 30 days, the predigested substrates were subjected to vermicomposting.

2.2. COLLECTION AND MAINTENANCE OF EARTHWORMS

The earthworm species, *E. eugeniae* and *E. fetida* chosen for the present study were collected from SACS Vermiery, Near Chatrapatty, Madurai District. The earthworms were acclimatized to the laboratory conditions for a period of 15 days before the commencement of the experiment.

2.3. VERMIBED PREPARATION

From the predigested materials of leaf litter and sugarcane trash, 5 kg from each lot was taken separately in three rectangular culture troughs of equal size (47 x 32 x16 cm). Among the three troughs, first one was without the earthworms, second and third with *E. fetida, E. eugeniae* respectively. Fifty earthworm species of *E. fetida* and *E. eugeniae* were introduced separately in the second and third troughs of leaf litter and sugarcane trash respectively. Water was sprinkled with regular intervals in all the troughs to maintain the temperature at 25˚ C and the troughs were covered with wet muslin cloth. The vermicomposting process was extended for a period of 45 days in three replicates.

2.4. BIOCHEMICAL ANALYSIS

Before introducing the earthworms into the troughs i.e. at the initial (0 day) and after 45^{th} day, the samples of compost and vermicompost were analyzed for the following biochemical components. The organic carbon was estimated following Walkey and Black method as described in Jackson (1973). The nitrogen content was determined by the modified Micro-Kjeldhal method (Umbreit *et al.*, 1974). The phosphorous was estimated according to the standard method of APHA (1998). The amount of potassium and calcium present in the samples were estimated with the help of Flame Photometry (Model CL – 22D).

2.5. POT EXPERIMENT

To examine the fertility of the leaf litter and sugarcane trash composts processed by earthworms, the vegetable plant, *Abelmoschus esculentus (*L) Moench, was selected. 3 kg of garden soil, composts and vermicomposts of the leaf litter and sugarcane trash were taken in separate individual pots and in each pot 10 seeds of *A. esculentus* were sown and maintained for a period of 50 days. Five replicates were maintained for each experiment. The data related to growth parameters of the plant i.e., height of the plant, number and area of leaves and length and weight of the fruits were observed and recorded at regular intervals. The total chlorophyll content of the matured leaves of control and experimental plants were estimated by following the method of Arnon (1949).

3. RESULTS AND DISCUSSION

The chemical composition of the vermicomposts produced from the leaf litter and sugarcane trash by the activity of the earthworms, *E. fetida* and *E. eugeniae* are presented in Tables 1&2. Statistical analysis revealed that the quantity of nitrogen, phosphorus, potassium and calcium is positively correlated with the duration of vermicomposting ($P< 0.05$). But the organic carbon and C/N ratio were negatively correlated with the advancement of vermicomposting.

Table 1: Nutrient composition of vermicompost of leaf litter processed by *E. fetida* and *E. eugeniae.* Each value represents the mean of (X ± S.D) 5 estimates

Parameters	0 day (Initial)	45th Day		
		Compost	Vermicompost processed by	
			E. fetida	*E. eugeniae*
Organic Carbon (%)	38.65 ± 0.65	30.48 ± 0.52	28.89 ± 0.81	28.00 ± 0.78
Total Nitrogen (%)	0.85 ± 0.03	1.01 ± 0.01	1.18 ± 0.02	1.30 ± 0.03
Phosphorus (%)	0.16 ± 0.01	0.25 ± 0.01	0.33 ± 0.02	0.38 ± 0.01
Potassium (%)	0.28 ± 0.02	0.43 ± 0.02	0.52 ± 0.03	0.57 ± 0.03
Calcium (%)	0.22 ± 0.03	0.51 ± 0.03	0.62 ± 0.05	0.70 ± 0.04

3.1. ORGANIC CARBON

The percentage of organic in the compost prepared from the leaf litter without earthworms has reduced from 38.65 to 30.48 % at the end of 45th day of the experiment. Maximum reduction in the organic carbon content was observed (28%) in the leaf litter vermicompost processed by earthworms, *E. eugeniae* than *E.fetida* (34.28%). The percentage of carbon has reduced from the initial day (44.54%) to the final day of sugarcane trash compost (39.13%). But it was tremendously reduced to 35.91 and 34.28% at the end of 45th day by the action of *E. fetida* and *E. eugeniae,* respectively. Similarly, Gajalakshmi *et al.,* (2005) reported a significant carbon decrease in the leaf litter processed by *E. eugeniae*. Garg *et al.,* (2005) have reported that reduction in total organic carbon was highest in agro-residues treated with *E. fetida.* Edwards and Lofty (1977) indicated that it is mainly due to combusting of carbon during respiration. Discussing the reduction of organic carbon, Mariappan *et al*., (2003) pointed out that decomposition of organic matter is brought about by living organisms that use more carbon than nitrogen as a source of energy and thus the amount of carbon is reduced to a more suitable level while nitrogen is recycled.

Table 2: Nutrient composition of vermicompost of sugarcane trash processed by *E. fetida* and *E. eugeniae.* (Each value represents the mean of (X ± S.D) 5 estimates)

Parameters	0 day (Initial)	45th Day		
		Compost	Vermicompost processed by	
			E. fetida	*E. eugeniae*
Organic Carbon (%)	44.54 ± 1.01	39.13 ± 2.03	35.91 ± 0.98	34.28 ± 2.99
Total Nitrogen (%)	0.74 ± 0.04	0.91 ± 0.02	1.12 ± 0.02	1.18 ± 0.04
Phosphorus (%)	0.12. ± 0.02	0.24 ± 0.01	0.26 ± 0.02	0.28 ± 0.01
Potassium (%)	0.16 ± 0.03	0.29. ± 0.02	0.37 ± 0.03	0.41 ± 0.01
Calcium (%)	0.19 ± 0.01	0.31 ± 0.01	0.53 ± 0.03	0.64 ± 0.03

3.2. TOTAL NITROGEN

The nitrogen content was comparatively higher (0.85%) in the leaf litter than the sugarcane trash (0.74%) at the initial stage and at the end of 45th day it had increased to 1.01% and 0.91% without earthworms. But the vermicompost prepared from the leaf litter showed a very high percentage of nitrogen (1.30%) by *E. eugeniae* than *E. fetida* (1.18%). The level of nitrogen was found to be 1.18% and 1.12% at the 45th day of vermicompost prepared from sugarcane trash processed by *E. eugeniae* and *E. fetida* respectively**.** Similarly, Parthasarathi and Renganathan (1999) reported that *E. eugeniae* increased the content of nitrogen 3.07 times over the ordinary compost. Sharma and Agarwal (2004) pointed out that earthworm casts contain five times more nitrogen than ordinary compost. The high degree of decomposition and mineralization increases high nitrogen content of soil which may fix atmospheric nitrogen in significant quantities and act as the source of nitrogen for plant growth (Hari *et al.,* 2004).

3.3. C/N RATIO

Maximum C/N ratio (60.19) was in sugarcane trash and it was found to be less in leaf litter (45.47) at the initial stage (Fig.1).

The C/N ratio of leaf litter degraded by both *E. fetida* and *E. eugeniae* had been reduced significantly to lower level (24.48 and 22.40) than the compost (30.18). The C/N ratio of the sugarcane trash vermicompost at the 45th day was found to be 32.06 and 29.05 processed by *E. fetida* and *E. eugeniae* respectively**.** The C/N ratio is an important factor affecting fertility of soil which is considerably altered by earthworms. Bansal and Kapoor (2000) reported that lowering of C/N ratio is due to loss of carbon in bacterial metabolism. Scanning of literatureshows that the optimum values for C/N ratio ranges from 20 to 31 (Sinha *et al.,* 2003; Zhu, 2007). Jeyabal and Kuppuswamy (2001) observed the C/N ratio of vermicompost reduced to 12–17:1 from 21–69:1 by *E. eugeniae.* The earthworm, *E. fetida* reduced the C/N ratio considerably in the compost prepared from agro wastes (Tripathi and Bhardwaj, 2003).

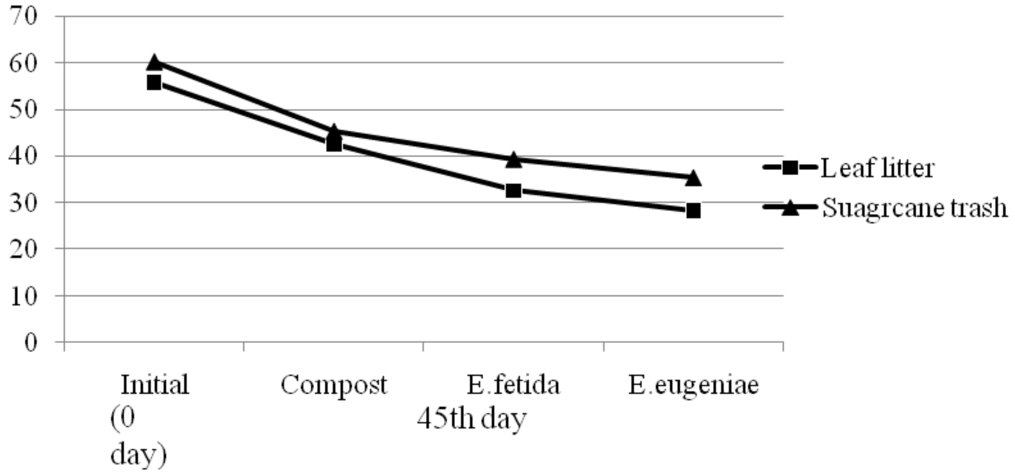

Figure 1: C/N ratio of composted leaf litter and sugarcane trash

3.4. PHOSPHORUS

At the commencement of composting, the quantity of phosphorus was 0.16 and 0.12% in leaf litter and sugarcane trash respectively. After 45 days, the compost without earthworms contained less amount of phosphorus (0.24 and 0.25%) than the vermicomposts obtained from sugarcane trash (0.26 and 0.28%) and leaf litter (0.33 and 0.38%) by the activities of *E. fetida* and *E. eugeniae* respectively. It is concluded that the phosphorus content was higher (1.08-1.52 times) in worm worked compost than the conventional composts. Sharma and Agarwal (2004) reported that earthworm casts contain seven times phosphorus more than ordinary soil. Garg *et al.,* (2005) noticed that the content of phosphorus had increased 1.4 to 6.5-fold in different substrates processed by *E. fetida* in comparison to control. Phosphorus increase is due to the microbial and phosphatase activity and increased solubility of phosphate in the vermicompost (Tiwari *et al.,* 1989). Scubler *et al*., (1998) reported that phosphorus is bound in organic matter in a form that is not available to plants; but mixing action of earthworms change it into a form that can be absorbed by the plant.

3.5. POTASSIUM

The potassium content of the compost obtained from leaf litter was higher (0.28%) than the sugarcane trash (0.16%) at the beginning of the composting. The leaf litter composted by *E. eugeniae* contained more potassium (0.57%) than sugarcane trash (0.41%). The earthworm, *E. fetida* was also very effective in increasing the content of potassium in the leaf litter compost (0.52%) and sugarcane trash (0.37%). Sharma and Agarwal (2004) reported that earthworm casts contain eleven times more potassium than ordinary compost. Basker, *et al*., (1993) pointed out that the potassium enhancement is due to shifting of non exchangeable to exchangeable form. Similar increasing trend in the level of potassium was noticed by Umamaheshwari *et al.,* (2004) in the vermicompost obtained through the action of *E. eugeniae.*

3.6. CALCIUM

The level of calcium at the initial stage was reported as 0.19 and 0.22% in sugarcane trash and leaf litter respectively. *E. eugeniae* increased the calcium level to 0.64 and 70 % in sugarcane trash and leaf litter after 45 days of composting. A similar trend in calcium increase was noticed in vermicomposts of both sugarcane trash (0.53%) and leaf litter (0.62%). This elevation may be due to microbes in the gut of earthworms and their metabolic process (Sudhakar *et al.,* 2002).

3.7. POT EXPERIMENT

Data related to the effect of different compost processed by *E. fetida* and *E. eugeniae* on the growth parameters of the vegetable plant, *Abelmoschus esculentus* is presented in Table 3. The results revealed that the plants grown on leaf litter vermicompost processed by *E. eugeniae* attained maximum height (61.4cm) compared to sugarcane trash vermicompost (56.75), composts without earthworms (leaf litter: 33cm; sugarcane trash: 25.8cm) and garden soil (20.3cm).

Table 3: Effect of leaf litter and sugarcane trash composted with earthworms on the growth parameters of *Abelmoschus esculentus* (after 50 days of life). Each value represents as mean (X ± S.D) of 5 observations

Parameters	Garden soil	Leaf litter			Sugarcane trash		
		C	Vc		C	Vc	
			Ef	*Ee*		*Ef*	*Ee*
Height of plant (cm)	20.3 ± 2.05	33.0 ± 1.84	54.8 ± 3.21	61.4 ± 3.25	25.8 ± 2.41	42.23 ± 4.46	56.75 ± 3.45
No. of leaves	7.1 ± 0.66	9.85 ± 0.81	13.6 ± 1.01	16.3 ± 1.15	8.62 ± 0.78	10.3 ± 0.81	14.3 ± 0.49
Leaf area (cm^2)	77.89 ± 5.1	118.24 ± 10.66	194.31 ± 8.6	265.23 ± 12.36	99.87 ± 10.2	164.23 ± 12.75	221.25 ± 15.32
Fruit length (cm)	7.6 ± 0.81	9.56 ± 0.95	14.2 ± 1.02	15.8 ± 1.51	8.5 ± 0.71	12.7 ± 1.25	14.9 ± 1.29
Fruit weight (gm)	10.6 ± 1.77	13.7 ± 1.24	15.1 ± 1.14	17.9 ± 1.81	11.5 ± 0.33	14.1 ± 1.28	16.7 ± 1.14
Chlorophyll (mg/g fresh wt.)	1.90 ± 0.73	2.51 ± 0.90	3.38 ± 0.89	3.78 ± 0.15	2.01 ± 0.88	2.86 ± 0.20	3.41 ± 0.22

C- Compost; Vc- Vermicompost; *Ef- E.fetida; Ee- E. eugeniae*

Similarly, other parameters including number (16/plant) and area of leaves (265.23cm^2), length (15.8cm) and weight (17.9gm) of the fruits, and chlorophyll content (3.78 mg/g fresh wt.) were greater in leaf litter vermicompost than the sugarcane trash processed by *E. eugeniae*. The results of the pot experiments have shown that the vermicompost of the tested organic waste highly altered the growth parameters of the plant *Abelmoschus esculentus*. Viveka *et al.,* (2005) observed the influence of vermicomposts in the growth and yield of bhendi plants. Ismail (2005) observed significantly higher yield of lady's finger, chillies, water melon and paddy by vermicompost application than farm yard manure. The positive effects of vermicompost on the tested plants may be because nutrients present in the worm cast are readily soluble in water for the uptake of plants (Bhawalkar and Bhawalkar, 1993). In the present investigation, leaf litter vermicompost showed higher values for the growth parameters of *Abelmoschus esculentus* than the sugarcane trash. This is due to the fact that nutrient status of vermicompost depends on the quality of waste materials used for processing by the earthworms as pointed out by Bohlen *et al.,* (1999). The leaf tissues of *A. esculentus* grown on leaf litter vermicompost showed high quantity of chlorophyll pigments than those reared on sugarcane trash composted with earthworms. Nithya *et al*., (2006) concluded that plants grown in soil amended with vermicompost show higher primary productivity by way of increased synthesis and elevated photosynthetic activity which in turn increase the yield of the plant.

From the present study it is revealed that of the two species of earthworms, *E. eugeniae* is highly efficient in composting the wastes into useful organic manure than *E. fetida*. This is because of its huge size, feeding rate, size and moisture content of the casts, microbial population and enzymatic action in the gut and casts as reported by Vinotha (1999).

4. CONCLUSIONS

The chemical analysis of the vermicomposts derived from leaf litter showed that the quantity of organic carbon was reduced from 38.65 to 28.89 and 28% by *E. fetida* and *E. eugeniae* respectively. The level of nitrogen, phosphorus, potassium and calcium was higher in vermicompost processed by *E. eugeniae* than *E. fetida* in both leaf litter and sugarcane trash. An ideal C/N ratio (22.40) was observed in leaf litter vermicompost processed by *E. eugeniae*. Similarly, *E. eugeniae* worked leaf litter vermicompost positively and significantly altered the height, number and area of leaves, fruit length and weight of *Abelmoschus esculentus.*

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